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BRIEF COMMUNICATION

SEASONAL VARIATION IN SALINITY IN THE WATERVALLEY WETLANDS IN THE SOUTH EAST OF SOUTH AUSTRALIA

The Watervalley Wetlands in the south east of South Australia are a group of shallow seasonal, ephemeral and permanent lakes and swamps which have been restored or rehabilitated between 1984 and 1995 (Fig. 1). They comprise a series of 15 wetland complexes totalling some 12,000 ha and are managed primarily for the conservation

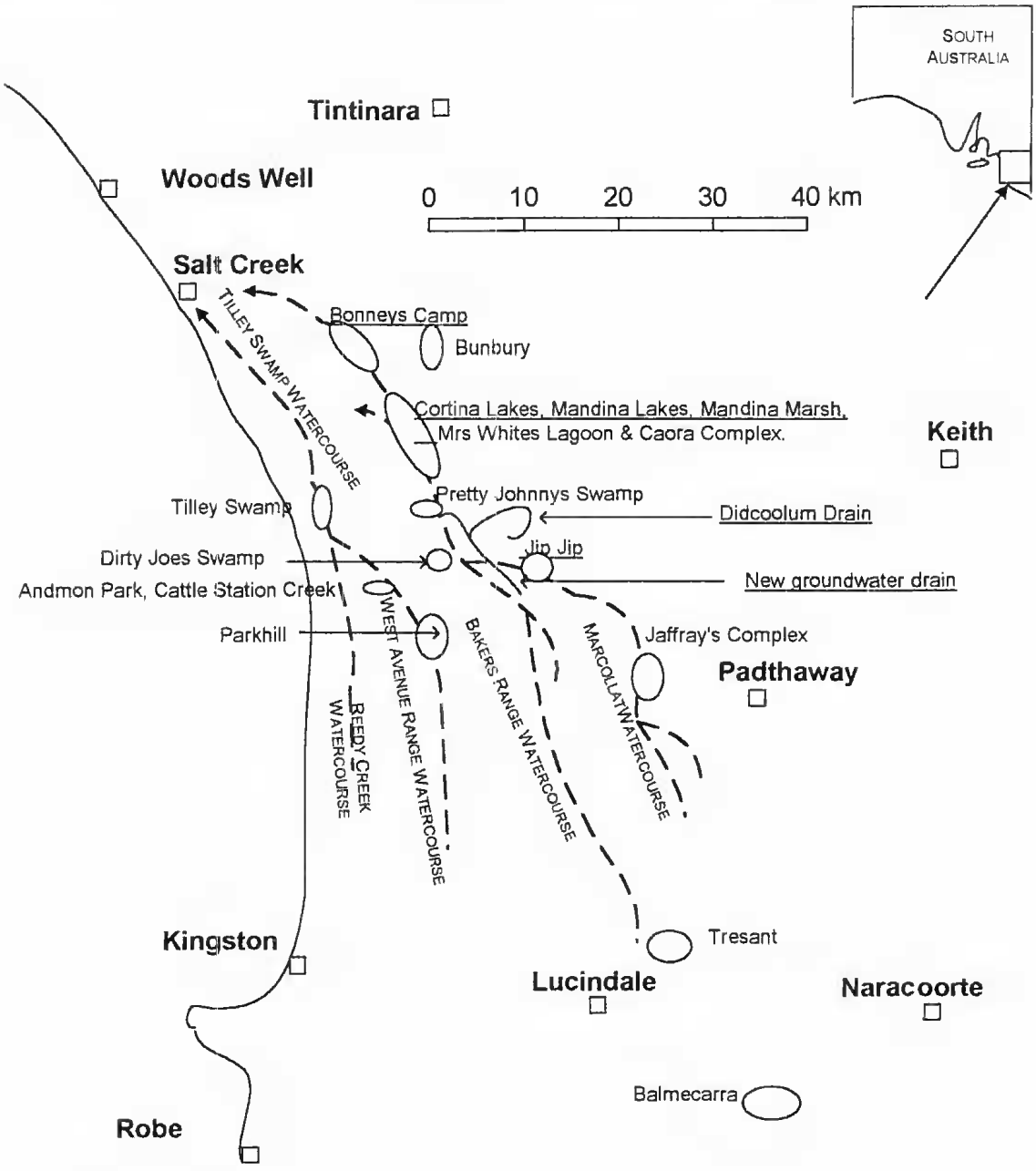

Fig. 1. The Watervalley Wetlands. Note: Sites mentioned in the text are underlined. Wetlands are not drawn to scale.

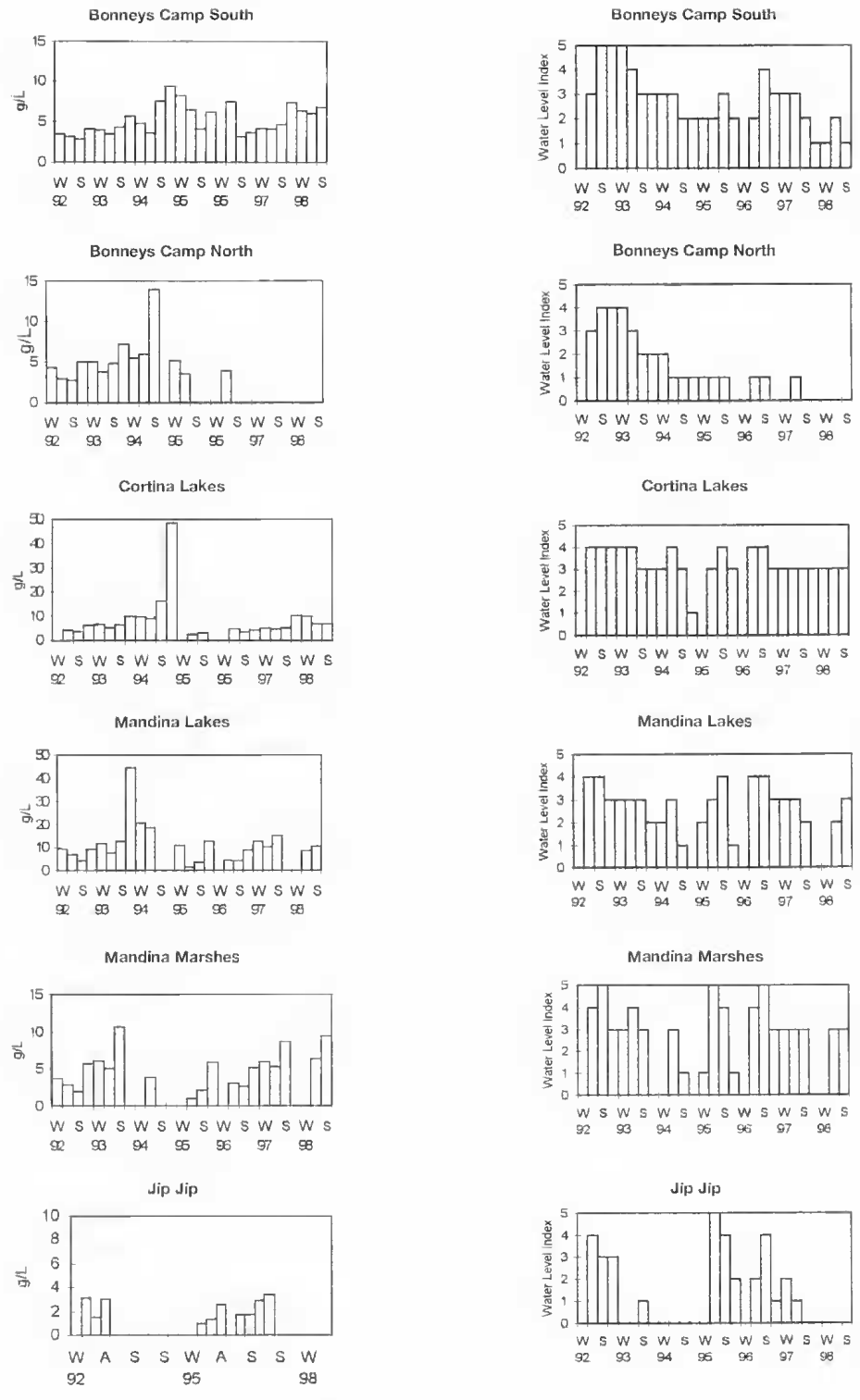

Fig. 2. Seasonal fluctuations of salinity and the concurrent Water Level Index in six of the Watervalley Wetlands. W = winter; S = summer. Note different scales for salinity of Cortina Lakes and Mandina Lakes. Except for winter 1996, no reading indicates that the sampling site was dry.

of waterbirds by a private conservation organisation, Wetlands and Wildlife, or by T. K. and P. A. Brinkworth. The majority of these wetlands fulfil the criteria for listing as Wetlands of International Importance under the Ramsar Convention and are a key component of the projected Wetlands Waterlink which will form a network of conserved wetlands from Bool Lagoon to the Coorong[1]. The major land use in the region is grazing by sheep and cattle. Much of the grazing land became available for agriculture only through the drainage of the original wetlands (92 % of which have been destroyed[1]) and now much of that land is threatened by soil salination. The waters of the remaining wetlands vary from fresh to saline but all wetlands that have been studied are subject to seasonal fluctuations in salinity.

White & Brake[2] described the ecological attributes, history and water chemistry of six of the Watervalley Wetlands. All six wetlands described (Jip Jip, Mandina Marshes, Mandina Lakes, Cortina Lakes and the south and north lagoons of Bonneys Camp) are fed largely by fresh to mildly saline water which flows along a system of man-made drains from catchments to the south east. The water reaches the northern wetlands only in years of above average rainfall in the catchment and flows through the wetlands in the listed order, terminating in the northern lagoon at Bonneys Camp. Salinity is highest in late autumn or early winter and lowest in spring (Fig. 2) whether or not fresh water enters the system from the south and, apparently, independently of run off from local rainfall. There is no significant correlation between local rainfall in the three months preceding sampling and salinity (at Bonneys Camp $r=0.1089$ and at Cortina $r=0.1763$). This supports the opinion that run off was a minor contributor to the water in the wetlands because of the porosity of the soils in the region[1]. The relationship between the wetlands and underlying groundwater has not been determined so the factor causing this winter depression in salinity is still a matter for conjecture. Between August 1992 and August 1994 there was a general upward trend in the levels of salinity and concern was expressed that this upward trend in salinity might continue[2]. The present paper reports on the salinity of the wetlands since August 1994 and comments on some previously discussed points.

Salinity was measured indirectly as conductivity (mS/cm) with an ACTIVON[SM] conductivity probe (which corrects readings to 25°C) on-site as described and discussed earlier[2], in autumn, winter, spring and summer (except for the winter of 1996) from 1992 to the present at each of the six sites listed above. Conductivity was converted to salinity in g/L by multiplying conductivity by 0.640. Water levels were scored using the Water Level Index (WLI) of Tamasier and Grillas[3]. The index scores water levels on a scale of 0 (empty) to 5 (overflowing). Seasonal fluctuations in salinity, together with the water level indices, are shown in Figure 2.

Salinity has also been recorded in the recently opened Didicoolum Drain on Petherick Rd from the time it was completed in March 1996 and in another drain which was completed in 1998 and which taps the local groundwater unlike the majority of drains in the region which carry surface water only. Water from both of these drains enters the system just south of Mandina Marshes. Mean readings for the Didicoolum Drain and the six previously mentioned sites as well as the two readings available from the new drain are given in Table 1. Rainfall figures are those for Tintinara, the nearest long-term official gauging station to the study sites, and Naracoorte, near the centre of the catchment area, and were obtained from the Bureau of Meteorology in Adelaide.

1993, 1994 and 1997 were years of lower than average rainfall in the study area (94, 79 and 72% respectively of the average of 470 mm at Tintinara) and in its catchment (83, 71 and 82% of the average 580 mm at Naracoorte) as was 1998 (80% at Naracoorte). In 1994-95 all of the sampling sites except the south lagoon at Bonneys Camp dried for periods of up to ten months and Jip Jip, Mandina Marshes, Mandina Lakes and the north lagoon of Bonneys Camp dried completely. All but Cortina Lakes and the south lagoon of Bonneys Camp dried again in 1998. Only the sampling site in the south lagoon of Bonneys Camp retained water throughout the study, but the water level dropped about a metre during the summer of 1994-95 and autumn 1995 and again over the corresponding period of 1997-98 reducing what is normally a continuous shallow lake to a series of isolated basins. Although the sampling site at Cortina Lakes dried in the late autumn and winter of 1995 water remained in other basins of the lake. Jip Jip was drained for maintenance of the outlet control in the summer of 1992 and again in the autumn of 1993 so the lengthy dry period in that wetland was abnormal.

Fresh water flowed from the drainage system into all of the wetlands except the north lagoon of Bonneys Camp during the late winter and spring of 1995 and again in 1996 but the new water did not reach the south lagoon of Bonneys Camp until after the spring readings were taken. Rainfall at Naracoorte in 1995 was 590 mm (long-term average = 580 mm) and a little below average at 555 mm in 1996 but this was still not sufficient to fill all of the wetlands after they had dried in the drought. With the return to below average rainfall in 1997 and 1998 all wetlands are currently well below capacity or dry.

When the flow of fresh water reached the wetlands in the spring of 1995 the salinity of the water quickly dropped to levels near, or below, those measured in the earlier part of the study in 1992, a year of above average rainfall (122% and 139% of the long-term mean for Tintinara and Naracoorte, respectively). The seasonal variation reported has continued but the general upward trend in salinity apparently has not, although at the time of writing conditions are again dry (1998 rainfall at Naracoorte was 486 mm) and salinities are increasing once more (Fig. 2). At the two sites with near permanent water, there is a significant negative correlation of salinity with Water Level Index ($r=-0.6586$, $p < 0.01$ at Bonneys Camp South and $r=-0.8358$, $p < 0.01$ at Cortina Lakes). White & Brake[2] predicted that Mandina and Cortina Lakes, wetlands which could not be drained but dried only by evaporation, were in danger of becoming increasingly saline each time they dried. This does not appear to be the case, at least in the short term. The patterns in salinity are similar in all systems.

The length of time needed to fill the system after it dries was not previously apparent. There has been insufficient water to reach the north lagoon of Bonneys Camp since water stopped flowing into it in January 1993. The wetlands in the south east region of Australia have long been recognised as crucial to the conservation of the nomadic water

TABLE 1. *Salinity of selected sites at Watervalley Wetlands 1992-1998.*

	Bonneys Camp S g/L.	Bonneys Camp N g/L.	Cortina Lakes g/L.	Mandina Lakes g/L.	Mandina Marsh g/L.	Jip Jip g/L.	Didi Drain g/l	New Drain g/L.
Mean	5.15	5.26	8.02	11.39	5.01	2.23	4.92	
SD	1.79	2.77	8.34	8.75	2.61	0.89	0.40	
Max.	9.31	13.95	44.35	44.35	10.75	3.41	5.50	7.48
Min.	2.82	2.75	2.31	1.52	1.00	0.93	4.04	6.28
No.	26	14	24	22	19	10	12	2

Didi Drain = Dideoolum Drain at Petherick Rd.

birds of Australia"[6]. Fifty per cent of the fresh water potentially available to these wetlands is currently drained out to sea and further drains are planned; a proportion of this new drainage water can be diverted to the wetlands and some has already begun to flow into the system. Evidence so far (Table 1 and unpublished data supplied by the South East Water Conservation and Drainage Board) indicates that some of the planned drains will be carrying groundwater of greater salinity than that which has previously entered the wetlands[1] but the measured salinity of those waters is within the limits of known salinities of the wetlands, particularly those in the northern part of the watercourses. Given these circumstances it is important to the long term viability of the Watervalley Wetlands, as well as to others in the region, that fresh water from the current and any future drains be made available to the wetlands wherever feasible. The Watervalley Wetlands are managed with the aim of maximising the diversity of species present. This requires a diversity of habitat and the varied salinity of the Watervalley Wetlands, which currently ranges from fresh (Jip Jip) to permanently saline (Mandina Lakes), provides such diversity. Saline lakes are generally more productive than freshwater systems[5] but a long-term increase in salinity in either the freshwater wetlands or the saline ones will inevitably lead to a state of constant hypersalinity and this in turn will lead to the exclusion of some species of waterbirds and plants which currently inhabit the wetlands[3,10]. Long-term monitoring of the consequences of the addition of more saline water to the wetlands is essential and this paper provides baseline information for future studies.

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JANICE M. WHITE, Centre for Environmental and Recreation Management, University of South Australia The Levels Campus Warrendi Road Mawson Lakes S. Aust. 5095.